Manchester Urban Ponds Restoration Program

YEAR 2 REPORT

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Acknowledgements

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Introduction

The Manchester Urban Pond Restoration Program (UPRP) is overseen by the Manchester Conservation Commission (MCC) and is part of a greater environmental effort in Manchester. As part of a solution to address Manchester's combined sewer overflows (CSOs), and improve environmental conditions, six Supplemental Environmental Projects (SEPs) were conceived. These six projects are: Environmental Education Curriculum Development, Children's Environmental Health Risk and Reduction, Stormwater Management, Streambank Stabilization, Wetlands/Land Preservation, and the Urban Ponds Restoration Program.

The UPRP was established in 2000 to assess the health of seven of Manchester's urban ponds (Crystal Lake, Dorrs Pond, Maxwell Pond, McQuesten Pond, Nutts Pond, Pine Island Pond, and Stevens Pond), and to take steps to restore these ponds by improving water quality. The UPRP hopes to restore these ponds to their historic uses such as swimming, fishing, and boating since over the years these activities have become difficult due to decreased water quality.

Manchester's urban ponds are quite different from one another and face unique challenges posed by the urban landscape that surrounds them. To better understand each pond, the UPRP has gathered baseline water quality data over the last two years, and has identified current and future water quality threats at each pond. The current water quality is described herein, and possible recommendations for the reduction of pollution inputs are outlined. Specific solutions to some pond issues include erosion control measures, urban runoff treatment measures, and proper trash disposal. The UPRP in conjunction with MCC can then make reasonable decisions regarding project prioritization based on short and long term goals for each pond.

This report is organized to allow for ease of reproduction of individual pond water quality sections. Comparisons between the ponds and the last two years of baseline data are included when appropriate.

Section I.
Field Work and Monitoring Parameters

Extensive fieldwork was conducted over the 2001 field season to develop a complete picture of the ecological conditions at Manchester's urban ponds. With the help of personnel from the NH Department of Environmental Services (DES), the NH Fish & Game Department (NHFG), the Manchester Conservation Commission (MCC) and other volunteers, the data collected at each pond included fish populations, fish contamination, sediment depth, sediment core contamination, water quality conditions and vegetation inventories.

Fish Surveys & Tissue Analysis

Fish surveys were conducted at Crystal Lake, Nutts Pond, Dorrs Pond and Pine Island Pond by the NH Fish & Game Department using electro-fishing equipment. Population data was recorded and a number of largemouth bass were collected from each pond for tissue analysis. Largemouth bass were selected as specimens due to their high position in the aquatic food chain. Analyses were conducted by Environmental Research Institute to determine metals, pesticides, and PCB's concentration in the fish tissue. Largemouth bass are also the likely species to be kept when caught by fishermen. The fish survey raw data tables are included in Appendix A.

Fish tissue analysis results were encouraging. All ponds showed relatively low levels of heavy metals with the exception of Pine Island, which showed elevated mercury levels. Nutts Pond had the highest levels of chromium, copper, manganese and zinc. Pesticides and polychlorinated biphenyls (PCBs) analysis results showed little to no bioaccumulation with just one parameter found above detectable limits at Crystal Lake. No pesticides or PCBs were found in fish at any of the other ponds. Tissue analysis tables are provided in Appendix A.

Healthy warm-water fish populations were found at all ponds sampled. Species found included largemouth bass, chain pickerel, black crappie, common sunfish, pumpkinseed sunfish, bluegill, yellow perch, white perch, brown bullhead, yellow bullhead, American eel, and white sucker. Nutts Pond seemed to exhibit a limiting factor since no largemouth bass greater than 2 pounds were found. Crystal Lake and Pine Island Pond exhibited very robust largemouth bass and sunfish populations. Several largemouth bass weighing more than five pounds were collected at both Crystal Lake and Pine Island Pond. Dorrs Pond also exhibited large populations of several warm-water species of fish.

Table 1 shows total fish survey results according to species. Stevens Pond was sampled in 2000 and the fish tissue analysis results are included in this report. Maxwell and McQuesten Ponds were not sampled due to site characteristic limitations.

Table 1
Summary of Pond Fish Sampling

Crystal Lake

Species	# sampled	Average Length (in.)	Average Weight (ounces)
Black Crappie	1	5.2	10.2
Bluegill	4	7.5	6.2
Common Sunfish	32	4.2	1.6
E. Chain Pickerel	4	11.4	5.2
Largemouth Bass	17	12.1	16.9
Yellow Perch	83	4.2	0.6
Total	141		

Dorrs Pond

Species	# sampled	Average Length (in.)	Average Weight (ounces)
Bluegill	20	7.0	4.8
Brown Bullhead	1	10.0	7.5
Common Sunfish	3	5.4	4.6
Common White Sucker	86	4.3	3.3
E. Chain Pickerel	21	10.9	5.6
Golden Shiner	8	8.3	6.7
Largemouth Bass	33	9.8	12.4
Yellow Bullhead	8	9.5	0.5
Yellow Perch	40	6.9	5.6
Total	220		

Nutts Pond

Species	# sampled	Average Length(mm)	Average Weight(gm)
Bluegill	13	6.0	3.4
Common Sunfish	70	3.9	1.1
E. Chain Pickerel	2	14.6	9.5
Golden Shiner	4	4.5	0.5
Largemouth Bass	57	7.9	6.3
Yellow Perch	14	5.5	1.8
Total	160		

Pine Island Pond

Species	# sampled	Average Length(in.)	Average Weight (ounces)
American Eel	5+~15	19.3	11.1
Black Crappie	5	8.8	5.8
Bluegill	34	4.2	1.3
Brown Bullhead	1	6.8	1.9
Common Sunfish	18	4.4	1.0
Common White Sucker	7	14.1	25.4
E. Chain Pickerel	1	7.7	1.4
Golden Shiner	2	3.6	0.2
Largemouth Bass	38	10.9	17.7
White Perch	64	8.6	4.7
Yellow Perch	34	5.4	1.0
Total	209		

Sediment Depth Mapping & Sampling

Sediment depth mapping was conducted at Dorrs, Nutts, and Stevens ponds during the winter of 2001 with the assistance of the NH Department of Environmental Services (NHDES). The remaining ponds (Crystal, Pine Island and Maxwell) will be mapped during the winter of 2002.

Sediment depth mapping was completed to determine to what extent the ponds have experienced sedimentation. This type of mapping had never been conducted on Manchester ponds therefore there exist no historical data to compare with the current sediment depths. The data gathered in 2001 establishes a sediment depth baseline that can be used as a measuring tool in the future.

Among all the ponds mapped, sediment depths ranged from 0 to approximately 24 feet. Dorrs Pond has not seen nearly as much sedimentation as the two other ponds mapped, due to the young age high flushing rate of Dorrs Pond. Nutts and Stevens Ponds are natural ponds. Dorrs Pond has only been impounded for approximately 230 years. The average sediment depths are as follows:

Dorrs Pond: Average = **2.24** feet; range 0 – 5 feet.
Nutts Pond: Average = **10.83** feet; range 0 – 18.7 feet.
Stevens Pond: Average = **13.22** feet; range 0 – 24.3 feet.

Sediment depths maps are included in Appendix B.

Sediment core samples were collected at all ponds except for McQuesten. These samples were analyzed for pesticides, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCB's) and metals contamination. Samples were taken at various sites according to their proximity to inlets or other areas of possible sediment contamination. Core samples were collected using a Glew sediment corer. Sediment analysis results are shown in Appendix B.

Vegetation Inventories

Vegetation inventories were conducted by Jen Drociak (Manchester Conservation Commission) to catalogue both native and invasive species, abundance, and locations. Identifying areas where invasive species occur is important when considering restoration options. All ponds had at least some invasive species present. Exotic plant species inventoried are listed in each pond informational section. A complete list of native plants inventoried is included in Appendix C.

Water Quality Sampling

The UPRP conducted water sampling at Manchester's seven urban ponds during the spring, summer, and autumn of 2001. The New Hampshire Volunteer Lake Assessment Program (VLAP) sampling procedure, coordinated by DES, was used as a template for these sampling field sessions. VLAP has also created summary reports for each pond. The detailed procedure for collecting water samples is included in Appendix D. All water sample analyses (except Total Phosphorus) were performed at the DES Limnology Center in Concord, NH, by DES personnel *. TP was analyzed by DES Laboratory Services. The raw water quality data is included in Appendix E.

Due to occasional equipment difficulties, and conflicting schedules, data gaps do exist. Given the different circumstances at each pond, the numbers representing the various parameters may not reflect that pond's water quality condition relative to any other of the ponds studied.

Water quality monitoring parameters included temperature, dissolved oxygen, pH, acid neutralizing capacity, conductivity, total phosphorus, chlorophyll *a* abundance, Secchi disk transparency, and turbidity. A brief explanation of each parameter follows. Table 2 compares the measured parameters in Manchester ponds to a “typical” NH lake.

* 356 separate analyses were performed by the NH DES Limnology Center, free of charge, which would have totaled **$3,130.00.**

Turbidity –107@ $10.00 each =	$1070
Conductivity – 96 @ $6.00 each =	$576
pH –96@ $6.00 each =	$576
Chlorophyll *a* – 28 @ $20.00 each =	$560
ANC – 29 @ $12.00 each =	$348

Table 2
Comparison of "Typical" New Hampshire Lake Values[1] to Manchester Pond Values[2]
2001 Sampling Season

Parameter	# of Lakes/Stns.	"Typical" NH Lake* Mean	"Typical" NH Lake* Median	Dorrs Pond Mean	Dorrs Pond Median	Maxwell Pond Mean	Maxwell Pond Median	Nutts Pond Mean	Nutts Pond Median	Pine Island Pond Mean	Pine Island Pond Median	Stevens Pond Mean	Stevens Pond Median	Crystal Lake Mean	Crystal Lake Median
pH	780	6.5	6.6	7.15	7.09	6.63	6.62	6.82	6.83	7.00	7.04	7.14	7.20	7.09	7.09
Alkalinity (mg/L)	781	6.6	4.9	21.7	21.9	9.8	9.6	17.3	17.0	20.1	21.0	31.0	32.7	17.3	16.0
Total phosphorus (mg/L)	772	---	.012	.024	.024	.018	.018	.023	.019	.016	.017	.025	.028	.012	.012
Conductivity (uMhos/cm)	768	59.4	40.0	831.3	851.0	154.6	148.5	714.2	630.5	383.3	412.5	1148.8	1128.0	439.7	444.0
Secchi disk (M)	663	3.7	3.2	1.3	1.1	>1.1	>1.1	2.4	2.6	1.9	1.7	2.5	2.6	3.5	3.5
Chlorophyll *a* (mg/m^3)	776	7.16	4.58	14.75	9.74	3.17	4.01	14.01	10.94	13.20	11.37	6.26	4.60	4.75	5.10

1) "Typical" values are summer epilimnetic values.

2) Manchester Pond Values are epilimnetic median and mean values.

* Estabrook, R. 2001. Interdepartmental Memo. NH DES. Water Division.

Temperature and Dissolved Oxygen

The dissolved oxygen (DO) concentration of a water body is directly related to water temperature. At colder temperatures, water holds more oxygen than at warmer temperatures. Thus, summer dissolved oxygen concentrations are typically lower than those collected in cooler months. Dissolved oxygen levels are key to the health of a pond ecosystem. Aquatic organisms cannot survive in extremely low oxygen environments.

A dissolved oxygen and temperature profile is determined by measuring DO and temperature at each meter of depth from the water's surface to the pond bottom. Pond stratification occurs when different temperatures exist at the top (epilimnion), middle (metalimnion), and bottom (hypolimnion) layers of the water column. Generally, the deeper a body of water, the more pronounced the stratification may become. This is mainly influenced by the amount of solar energy that reaches each water layer. As the sun becomes lower in the sky in the fall, thermal stratification lessens and usually disappears completely by winter. Deeper ponds experience pronounced thermal stratification, while in shallower ponds stratification is subtler, if present at all. Due to biological processes that consume oxygen at the pond bottom, some ponds incur a dissolved oxygen deficit in the hypolimnion (bottom layer).

"Typically, the deeper the reading, the lower the percent saturation of oxygen. Colder waters are generally able to hold more dissolved oxygen than warmer waters, and generally, the deeper the water, the colder the temperature. As a result, a reading of 9 milligrams/Liter (mg/L) of oxygen at the surface will yield a higher percent saturation than a reading of 9 mg/L at 25 meters, because of the difference in water temperature." (NH DES, 1999).

pH

The lower the pH of water, the more acidic the water. The higher the pH of water, the more alkaline the water. Pond pH is crucial to the well being of pond dwelling organisms. A pH of less than 5.5 (acidic) has detrimental effects on fish growth and reproduction. A pH between 6.5 and 7.0 is considered ideal for freshwater ecosystems. The median pH for New Hampshire lakes is 6.7. (NHDES, 1999). The median pH for Manchester's ponds is 7.07.

Acid Neutralizing Capacity

Acid Neutralizing Capacity (ANC) describes the ability of water to buffer against acidic inputs, such as acid rain. This is also known as a lake's alkalinity. The higher a water body's ANC, the better it's ability to buffer acidic inputs. Lakes with low ANC, typical of New Hampshire, are especially vulnerable to the effects of acid precipitation.

A desirable ANC for any lake is greater than 20 mg/L of Calcium carbonate (CaCO). The average ANC for New Hampshire lakes is 6.5 mg/L. (NHDES, 1999.) The average ANC for Manchester's ponds is 19.5 mg/L.

Conductivity

Conductivity, also known as specific conductance, is a measure of the ability of water to conduct an electric current. This is determined by the number of ionic particles present in the water. High conductivity values may be indicative of non-point source pollution, but may be affected even more dramatically by natural geologic features of the watershed.

Conductivity values for New Hampshire lakes that are greater than 100 micro Mhos (uMhos) are most likely indicative of anthropogenic sources of excess ions in the water, since the average conductivity for New Hampshire lakes is 56.8 uMhos. Anthropogenic sources include urban runoff (metals, sodium), and agricultural runoff (sediment, phosphorus). (NHDES, 1999.) The average conductivity for Manchester's ponds (epilimnion or upper layer) is 611.9 uMhos.

Phosphorus

Phosphorus is the nutrient that often limits algal production in lakes and ponds. Without excess phosphorus in the system, algal production is hindered and nuisance algal blooms do not occur. As phosphorus amounts increase, so do alga concentrations.

Phosphorus exists as a natural element, but becomes a problem when inputs from such sources as septic systems, erosion, animal wastes, and fertilizer load the water body with excess amounts. The median phosphorus concentration in the epilimnion of New Hampshire lakes is .011 mg/L. (NHDES, 1999.) The median phosphorus concentration for Manchester's ponds (epilimnion) is .019 mg/L.

Chlorophyll-*a*

The concentration of chlorophyll *a* is an indicator of algal abundance. Because of the presence of chlorophyll *a* pigment in algae, the relative concentration of chlorophyll *a* in the water gives an indication of the concentration of algae. As the alga population increases, so does the chlorophyll *a* concentration.

Chlorophyll *a* concentrations greater than 10.0 mg/m^3 usually indicate an algal bloom. The mean chlorophyll *a* value for New Hampshire lakes is 7.47 mg/m^3. (NHDES, 1999.) The mean chlorophyll *a* concentration for Manchester's ponds is 9.36 mg/m^3.

Secchi Disk Transparency

A secchi disk measures the depth that one can see into the water. To measure Secchi disk transparency, a black and white patterned disk is lowered into the water, and the depth at which it is no longer visible is recorded. This is indicative of actual water clarity, which is affected by the amount of algae and particulate matter (turbidity) in the water column. Secchi disk readings are somewhat subjective, but generally correlate with chlorophyll *a* concentrations and turbidity levels.

The mean transparency for New Hampshire lakes is 3.7 meters. (NHDES, 1999.) The mean transparency for Manchester's ponds is 2.1 meters.

Turbidity

Turbidity is a measure of suspended matter in the water. The more material (clay, silt, algae) suspended in the water, the higher the turbidity. These materials cause light to be scattered and absorbed, instead of transmitted in straight lines, leading to decreased water clarity. High turbidity readings are often found in water adjacent to construction sites, or waters otherwise polluted. (NHDES, 1999.)

The median turbidity for New Hampshire lakes is 1.0 NTU. (NHDES, 1999.) The median turbidity for Manchester's ponds is 1.55 NTU.

Section II.
Manchester's Ponds

A description of findings for each of Manchester's Pond follows. Summary data tables are also provided.

Crystal Lake

Total Phosphorus

The total phosphorus concentration (TP) measured in the epilimnion of Crystal Lake ranged from 0.011 to 0.013 mg/L, with a mean of 0.012 mg/L. This average is slightly higher than that recorded in 2000 by the Manchester UPRP. The mean TP published in the 1985 DES Diagnostic/Feasibility report was 0.016 mg/L, 0.004 mg/L higher than the 2001 mean. The highest TP value recorded in the hypolimnion in 2001 was .018 mg/L., and the average was .017 mg/L. This is an average reduction of .026 mg/L since the 1981-1982 DES readings.

Conductivity

Conductivity in the epilimnion ranged from 417 to 458 uMhos/cm, with an average of 439.7 uMhos/cm. This is an increase of 122.7 uMhos/cm over the 1981-1982 DES average. This is also a slight increase from the 2000 average epilimnion conductivity of 418.7 uMhos/cm.

Chlorophyll-*a*

Composite values for chlorophyll *a* for the upper 3 meters ranged from 2.37 to 6.78 milligrams/cubic meter (mg/m^3), with a median of 5.1 mg/m^3. This is a reduction of 17.07 mg/m^3 since 1985, when the median measured 22.17 mg/m^3. However, this is a slight increase from the 2000 median of 2.72 mg/m^3. Secchi disk transparency ranged from 2.4 to 4.75 meters, with a median of 3.5. This is an increase in transparency since '81-'82 when the median value was 3.0 meters, but a decrease since the 2000 season when the median was 4.5 meters. These numbers indicate a direct relationship between chlorophyll *a* content and water transparency.

pH and Acid Neutralizing Capacity

The pH of Crystal Lake ranged from 7.01 to 7.16, with a median of 7.09. This is slightly lower than pH readings in the 1985 study, when the median was 7.2. This difference may be attributed to the fact that pH rises in the presence of higher algal concentrations. Acid Neutralizing Capacity (ANC) ranged from 14.7 to 21.2 mg/L of CaCO with an average of 17.3 mg/L of CaCO. This is slightly lower than the 1985 DES average of 19.8 mg/L of CaCO.

Turbidity

Turbidity in Crystal Lake was relatively low ranging from 0.75 to 0.96 with an average of 0.89 (NTU). This is almost double the turbidity level found in 2000.

Overall Water Quality

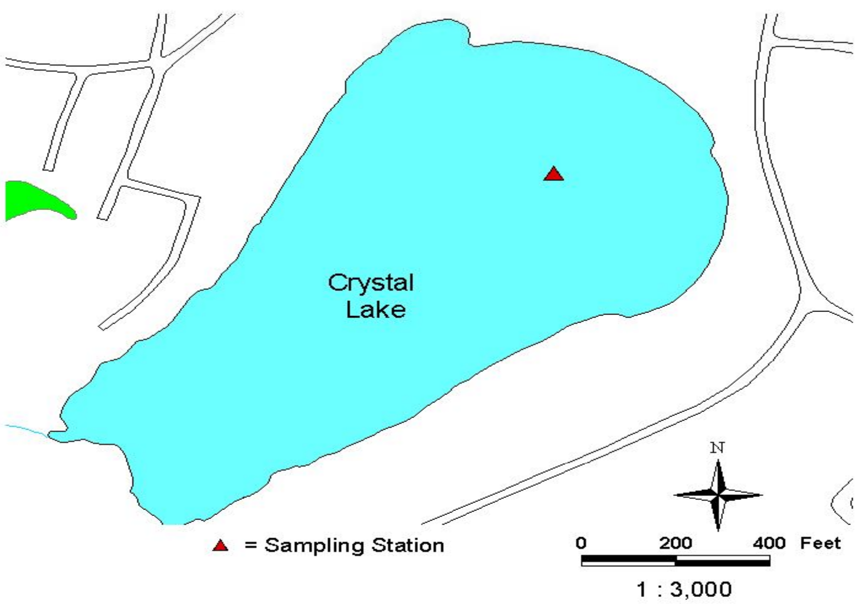
The water quality of Crystal Lake remains relatively unchanged since conditions were documented in 1981. Impacts from shoreline development have left their mark in the form of eutrophication, but rapid water quality decline does not seem to be apparent.

Table 3[1]
Comparison of Crystal Lake – 1981*, 1985, 1997+ , 2000 & 2001**

Parameter	7/14/1981	1985 Median	6/30/1997	2000 Mean	2000 Median	2001 Mean	2001 Median
pH	7.3	7.2	7.1	6.99	6.94	7.09	7.09
Alkalinity (mg/L)	21.9	20.8	16.1	18.1	18.8	17.3	16.0
Total phosphorus (mg/L)	.043	0.02	.019	.011	.011	.012	.012
Conductivity (uMhos/cm)	317	316	342	418.7	418.0	439.7	444.0
Secchi disk (m)	2.0	3.0	4.5	4.3	4.5	3.5	3.5
Chlorophyll a (mg/m3)		22.17		3.39	2.72	4.75	5.10

1) All values are epilimnetic values, except chlorophyll *a* which is a composite.
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.
** Estabrook, R., et al. 1985. Urban Lakes Diagnostic/Feasibility Study. Staff Report No. 140. New Hampshire Water Supply and Pollution Control Commission.
+ NH Dept. of Environmental Services. 1998. Lake Trophic Data.

Figure 1 – Crystal Lake Sampling Stations



Vegetation Inventory

A vegetation inventory was conducted at Crystal Lake on August 24, 2001. The following is a list of exotic plant species found at Crystal Lake. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

<u>Emergent</u>

- Common Reed *(Phragmites communis)*

<u>Upland Shrub</u>

- European Buckthorn *(Rhamnus frangula)*
- Honeysuckle *(Lonicera spp)*
- Japanese or European Barberry *(Berberis vulgaris/thunbergi)*

The invasive species *Phragmites communis,* or common reed, has begun impacting recreational uses of Crystal Lake. The northwest shoreline of the lake is dominated by *Phragmites*.

Fish Tissue Analysis

Crystal Lake Largemouth bass contained small amounts of chromium, copper, manganese, selenium, zinc and mercury. None of these metals were found in high enough concentrations to constitute a health risk to humans. A constituent of the pesticide DDT (p,p'-DDE) was also found in the Crystal Lake fish samples. This is very common the environment and does not represent a risk to humans. No other contaminants of note were found above detectable limits. Fish tissue analysis tables are included in Appendix A.

Sediment Sample Analysis

Crystal Lake sediment core samples showed no pesticides, PCBs, or PAHs above detectable limits and no metals of noteworthy levels. Sediment data tables are included in Appendix B.

Current Status

The health of Crystal Lake has been the focus of the efforts of the Crystal Lake Preservation Association (CLPA) since their inception in 1994. In 1999, the CLPA was awarded a grant from DES to install a new stormwater treatment system – the StormTreat system. This system now treats runoff from Bodwell Road and adjacent parking areas before it enters the lake. With this installation, one of only three surface water inlets is now being treated.

CLPA has also been active in attempts to preserve certain tracks of land adjacent to the lake that are threatened by residential development. This area, known as the Filip's Glen subdivision, is the only remaining open space in proximity to the lake. It is important for the long-term health of the lake that this area be developed only in the most environmentally sensitive way possible. Plans are currently in place to purchase a portion of the property proposed for development. The developer has donated the largest wetland portion of the property to the CLPA. This particular portion is the closest to the lake of all the properties in question. A significant amount of the Urban Ponds Restoration Program budget has been allocated for the ultimate purchase and preservation of large portions of the Filip's Glen subdivision property to help preserve the water quality of Crystal Lake.

Also underway is a project to install best management practices (BMPs) at an outfall that collects runoff from the public parking area for Crystal Lake Beach. This outfall contributes large amounts of sediment and nutrients to the lake during every rainfall. A series of catch basins drain the entry road and parking area and are connected to a culvert that outfalls at the north end of the beach. A sediment delta has developed here over the years. Preliminary plans have been designed to install a settling basin and grassed swale to remove sediment and nutrients at this location. The City of Manchester Highway Department has been very helpful in developing this project.

Dorrs Pond

Dissolved Oxygen

Hypolimnion dissolved oxygen readings varied greatly from month to month at Dorrs Pond. This may be due to the shallow area in which readings were taken. The sampling station is relatively close to the dam/outlet which creates a current in this area. Factors influencing pond flow, such as precipitation, may also influence dissolved oxygen concentration in this particular area. Summer dissolved oxygen levels were typically depleted in the hypolimnion but levels were more uniform throughout the water column during the spring and fall.

Total Phosphorus

The total phosphorus concentration (TP) measured in the epilimnion of Dorrs Pond varied from .014 to .034 mg/L, with a mean of .024 mg/L. This is a significant reduction of 53% from TP levels measured in 2000. When the pond was stratified, TP in the lower level or hypolimnion peaked at 0.036 mg/L and averaged 0.029 mg/L. This is also a sharp reduction compared to 2000. Two of the pond's main inlets are still significant sources of phosphorus input, even with apparent reduction from last year. Lessard's Brook averaged 0.035 mg/L of TP (20% reduction from 2000) and Inlet 2 East averaged 0.024 mg/L of TP (62% reduction from 2000). The '81-'82 DES study found a median of .042 mg/L TP in the epilimnion, 43% higher than 2001 levels. Twenty years apparently have not significantly changed phosphorus inputs to Dorrs Pond. However, the 2001 data seem to show great reductions. Possible explanations for this are discussed the "Short Term Changes" section. These inlets drain highly urbanized areas. See Table 1 for a comparison between 1985, 2000 and 2001 values.

Conductivity

Conductivity in the epilimnion ranged from 708 to 915 uMhos/cm, with a mean of 831 uMhos/cm. When the pond was stratified, the hypolimnion conductivity averaged 825 uMhos/cm. This is more than twice the conductivity levels recorded in 2000. As expected, the inlets also were highly conductive, averaging 814 and 876 uMhos/cm each. These are very high conductivity levels, most likely caused by the large amount of urban runoff that this location receives. Conductivity levels have risen by approximately 69% since 1985.

Chlorophyll-*a*

Composite values for chlorophyll *a* for the upper 1.5 meters ranged from 5.45 to 34.06 mg/m^3, with a median of 14.75 mg/m^3. This was lower than the 1985 DES findings, where the median was 38.84 mg/m^3 and also lower than the 2000 readings when the average was 30.84 mg/m^3. These readings indicate a highly productive water body. DES considers concentrations greater than 30 mg/m^3 to be a nuisance amount that is indicative of an algal bloom. Composite samples are derived from combining water samples from each meter of the water column from the midpoint of the metalimnion (middle layer) to the surface.

Transparency

Secchi disk transparency ranged from 1.1 to 1.7 meters, with a median of 1.3 meters. The minimum transparency was recorded in June. Water clarity and chlorophyll *a* concentrations seem to be vaguely related since water clarity is low and chlorophyll *a* concentrations are high. This idea is supported by the fact that chlorophyll *a* concentration decreased overall since 2000 and secchi disk transparency improved during that same time period. The 1985 DES Secchi disk transparency readings were slightly deeper, with a median of 1.6 meters. However, 1985 also saw high chlorophyll *a* levels in Dorrs Pond.

pH and Acid Neutralizing Capacity

The pH of Dorrs Pond ranged from 7.08 to 7.28, with an average of 7.15. pH values in the 1985 DES study were not significantly different than those taken in 2000 or 2001. The 1985 median was 7.0. Alkalinity, or Acid

Neutralizing Capacity (ANC) ranged from 15.9 to 27.1 mg of CaCO/L, with an average of 21.7 mg/L in 2001. This is an increase of 25% since 2000. The 1985 DES alkalinity median value was 15.4 mg/L of CaCO.

Turbidity

Turbidity of epilimnion samples ranged from 2.5 to 5.0 (NTU), with an average of 3.7 (NTU) in 2001, roughly the same as in 2000. This was the highest turbidity recorded in any Manchester pond. High turbidity is most likely caused, in this case, by a large volume of urban runoff to this location. Turbidity measurements were not taken at Dorrs Pond during the 1985 DES Diagnostic/Feasibility Study.

Overall Water Quality

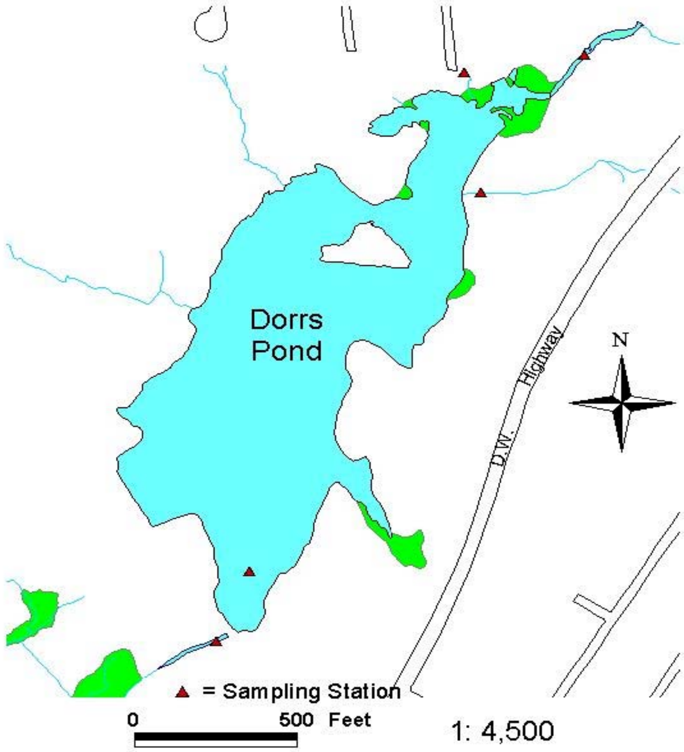
The overall water quality of Dorrs Pond has not significantly changed over the last twenty years, though it is slightly more degraded now, even with the continuing development in the watershed. The approximately 134 acres of city-owned forested woodland which surrounds the pond has prevented pondside development, thus providing the pond a reprieve from receiving any more direct urban runoff than it historically has.

Table 4[1]
Comparison of Dorrs Pond – 1981*, 1985, 1997+, 2000 & 2001**

Parameter	7/14/1981	1985 Median	7/17/1997	2000 Mean	2000 Median	2001 Mean	2001 Median
pH	6.8	7.0	7.1	7.08	7.08	7.15	7.09
Alkalinity (mg/L)	13.9	15.4	22.2	16.2	---	21.7	21.9
Total phosphorus (mg/L)	.060	.042	.031	.045	---	.024	.024
Conductivity (uMhos/cm)	201	258	469	408	---	831.3	851.0
Secchi disk (m)	1.3	1.6	1.3	1.1	1.0	1.3	1.1
Chlorophyll a (mg/m3)		38.84		30.84	---	14.75	9.74

1) All values are epilimnetic, except chlorophyll *a* which is a composite.
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.
** Estabrook, R., et.al. 1985. Urban Lakes Diagnostic/Feasibility Study. Staff Report No. 140. New Hampshire Water Supply and Pollution Control Commission.
+ NH Dept. Of Environmental Services. 1998. Lake Trophic Data.

Figure 2 – Dorrs Pond Sampling Stations



Vegetation Inventory

A vegetation inventory was conducted at Dorrs Pond on August 3, 2001. The following is a list of exotic plant species found at Dorrs Pond. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

Emergent

- Purple Loosestrife *(Lythrum salicaria)**

Upland Shrub

- European Buckthorn *(Rhamnus frangula*)*
- Honeysuckle *(Lonicera spp.)**
- Japanese Knotweed *(Polygonum cuspidatum)* *
- Oriental Bittersweet *(Celastrus orbiculata)**

Fish Tissue Analysis

Dorrs Pond largemouth bass tissue sample analysis found chromium, copper, manganese, selenium, zinc and mercury. None of these metals were found in high enough concentrations to constitute a health risk to humans. No other contaminants tested were found above detectable limits. Fish data tables are included in Appendix A.

Sediment Sample Analysis

Dorrs Pond sediment core samples contained high levels of several metals. Copper, lead, manganese, mercury, nickel and zinc were found to be exceeding the "severe effects level" criteria for aquatic organisms. The pesticide DDT constituent p,p'-DDE was also found to exceed the "lowest effects level" criteria for aquatic organisms. Sediment data tables are included in Appendix B.

Current Status

In 1997 the Dorrs Pond Preservation Society (DPPS) was awarded a Section 319 local watershed initiative grant from DES to perform stormwater improvements on the main tributary to the pond. In December 2001, a Downstream Defender was installed to catch runoff from Northside Plaza, and separate sediment and floatables before entering the main tributary to Dorrs Pond. Through a collaborative effort, the Manchester Highway Department installed the 8-foot wide swirl separator structure adjacent to an existing drainage swale under Northside Plaza. This should significantly improve the water quality of this tributary. Monitoring will be carried out this year to determine the unit's effectiveness.

Another grant was awarded to MCC in January 2002 for a water quality improvement project on a tributary on the pond's east side. The grant, Section 319 local watershed initiative funds, will pay for design and construction of a water quality inlet device and wetland swale system. The tributary (East Inlet 2) collects runoff from approximately 66 acres of mixed-use land including a residential neighborhood and several large active commercial/industrial lots. The system will be designed to remove sediments and associated nutrients in stage one (swirl separator) and remove dissolved nutrients and metals in stage two (wetland swale). The project work is expected to take place during the summer and fall of 2002.

Trail improvements are also scheduled for the near future around the pond. In 2001, the Manchester Parks Recreation and Cemetery Department received a grant from the Land and Water Conservation Fund to carry out a major trail improvement project at Livingston Park. The grant was matched by a private local fund. The improvement plan will consist of trail improvements, handicap accessibility through approximately 50% of the trail network, boardwalk and bridge construction and viewing areas with benches. Bridges will be installed over seasonal stream crossings lessening the likelihood of stream channel disturbance and erosion.

Meanwhile the DPPS continue their successful periodic clean up and educational efforts.

Maxwell Pond

Dissolved Oxygen

Dissolved oxygen levels were relatively high in relation to other Manchester ponds due to the stream-like characteristics of Maxwell Pond. The lowest dissolved oxygen saturation recorded at Maxwell Pond was 43.0% at the pond's deepest point. DO levels in 2001 were very similar to those found in 2000.

Total Phosphorus

Due to the fact that the deepest spot in Maxwell Pond is 1.1 meters, there was no thermal stratification, so only "surface grab" samples were necessary for in-pond sampling. Total phosphorus concentrations ranged from 0.013 to 0.023 mg/L, with an average of 0.018 mg/L. According to data from DES Trophic Classification of NH Lakes and Ponds, 1981, Maxwell Pond TP concentration was 0.018 mg/L. These two years of data (1981 and 2001) are similar but higher than 2000 levels. This shows fluctuations in TP concentrations over the years. Due to the high turnover of pond volume and shallowness here, inlet samples are especially important. TP concentrations in the inlet samples (Black Brook) never rose above 0.016 mg/L and averaged 0.012 mg/L. This is slightly lower than inlet TP concentrations in 2000.

Conductivity

Conductivity of Maxwell Pond ranged from 124.1 to 206.0 uMhos/cm, with an average of 154.6 uMhos/cm. DES 1981 data shows conductivity at 56.0 uMhos/cm. 2001 saw a 22% rise in conductivity over 2000, and a 176% rise over 1981. Inlet samples ranged from 122.4 to 233.0 uMhos/cm and averaged 167.6 uMhos/cm in 2001. This is a 28% rise from 2000. Clearly, something is causing a significant increase in conductivity at Maxwell Pond. Future investigations will attempt to identify the cause(s) of the increase in conductivity.

Chlorophyll-*a*

In-pond chlorophyll *a* concentrations were very low, ranging from 1.11 to 5.45 mg/m^3, and averaging 3.17 mg/m^3. These low readings are most likely due to the pond's high flushing rate. Though still relatively low, the 2001 average is approximately double the 2000 average.

Transparency

As the bottom could clearly be seen at 1.1 meters, Secchi disk transparency was >1.1 meters and could not be measured more accurately due to lack of depth.

pH and Acid Neutralizing Capacity

The pH of Maxwell Pond ranged from 6.45 to 6.87, averaging 6.63. 2000 pH readings at Maxwell Pond were similar to those found in 2001. This is slightly low for NH freshwater ecosystems, but still well within the range for supporting aquatic life. pH readings by NH DES in 1981 were similar at 6.4. ANC was also consistently lower than other Manchester ponds, ranging from 4.0 to 16.7 mg of CaCO/L, with an average of 9.8 mg/L. In 1981, NH DES found ANC to be 6.4 mg/L. Maxwell is therefore less able to buffer acidic inputs, which may help explain the low pH readings.

Turbidity

Turbidity in Maxwell Pond ranged from 0.94 to 4.3 (NTU) and averaged 3.39 (NTU). This is a slight increase from 2000 when the average turbidity was 2.03 (NTU). NH DES 1981 turbidity readings were a bit higher at 4.3 (NTU).

Maxwell Pond appears to be showing a slight trend of decreasing water quality since 2000. Two years of data, however, do not accurately represent a trend. Natural fluctuations, upstream disturbances and discharges, and precipitation variations could all be singled out as reasons for water quality fluctuations.

Overall Water Quality

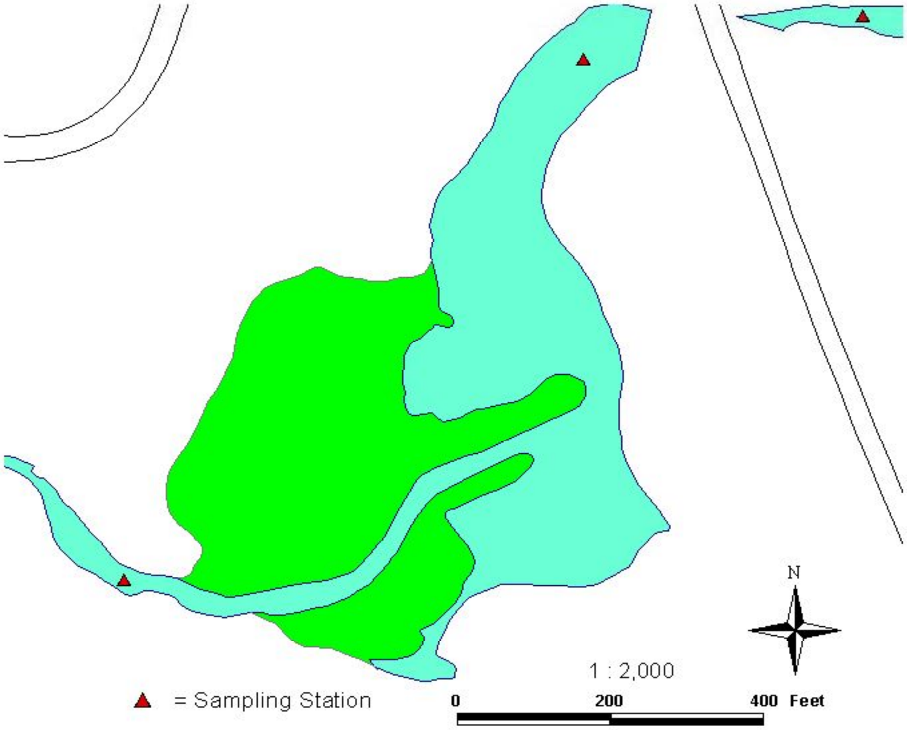
The water quality of Maxwell Pond is better than any other Manchester Pond. Maxwell has a very high turnover rate and relatively little urban development in the watershed. Its streamlike characteristics allow most pollutants to wash downstream. Rapid sedimentation, due to the dam, and vegetation growth is occurring in some parts of the pond, however.

Table 5[1]
Comparison of Maxwell Pond – 1981*, 2000 & 2001

Parameter	1981	2000 Mean	2000 Median	2001 Mean	2001 Median
pH	6.4	6.54	6.55	6.63	6.62
Alkalinity (mg/L)	7.0	6.8	6.9	9.8	9.6
Total phosphorus (mg/L)	.018	.014	.014	.018	.018
Conductivity (uMhos/cm)	56.0	121.8	127.3	154.6	148.5
Secchi disk (m)	>1.2	>1.1		>1.1	

1) All values are epilimnetic.
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.

<u>**Figure 3 – Maxwell Pond Sampling Stations**</u>



Vegetation Inventory

A vegetation inventory was conducted at Maxwell Pond on August 3 and August 27, 2001. The following is a list of exotic plant species found at Maxwell Pond. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

<u>Emergent</u>
- Purple Loosestrife *(Lythrum salicaria*)*

<u>Upland Shrub</u>
- European Buckthorn *(Rhamnus frangula)**
- Honeysuckle *(Lonicera spp.)**
- Japanese or European Barberry *(Berberis vulgaris)**
- Oriental Bittersweet *(Celastrus orbiculata)**

Maxwell Pond riparian areas are dominated by invasive wetland and upland plant species.

Sediment Sample Analysis

Maxwell Pond sediment core samples showed elevated levels of chromiun, copper, lead, manganese, mercury, nickel and zinc. All of these metals exceeded the "lowest effects level" but not the "severe effects level" criteria for aquatic organisms. The pesticide DDT constituent, p,p'-DDE also exceed the "lowest effects level" for aquatic organisms.

Current Status

Plans are currently being discussed for possible dam removal at Maxwell Pond. This would drastically alter Maxwell Pond as we know it. In partnership with DES and Trout Unlimited the UPRP will assist with a feasibility study at Maxwell Pond to determine baseline conditions, and formulate hypotheses regarding the reaction of Black Brook to dam removal. Identification of existing channel location and conditions as well as historic, pre-dam channel characteristics is crucial to understanding the long term effects that dam removal may have on this site and the Black Brook corridor as a system. The dam removal study workplan will include aerial topographic surveying, stream channel morphology study, bathymetric survey and sediment depth mapping of Maxwell Pond, water quality monitoring of Maxwell Pond, and biomonitoring of Black Brook including macroinvertebrate surveys and fish surveys. If the dam is removed, approximately six miles of free-flowing stream would be restored.

Trout Unlimited was awarded a $13,850 grant from the NH DES local watershed initiative grant program to conduct the first phase of the Black Brook corridor study: photogrammetric mapping. The product will be an up-to-date aerial topographic map accurate to a contour interval of one foot.

Concurrent with dam removal study, a restoration plan is being created for a disturbed site upstream of Maxwell Pond. A concrete aggregate and transportation operation has been impacting Black Brook for several years. Impacts include channel obstruction and filling as well as sedimentation and artificial bank armoring. The property owner has been cooperating with DES authorities to remedy the problems on the site, as well as reconfigure stream crossings to allow proper fish passage and possibly relocate the stream channel to its historic location.

McQuesten Pond

Inlet and outlet samples were taken at McQuesten Pond, with very few in-pond samples. McQuesten Pond is less than 18 inches deep in any spot, therefore in-pond sampling was not all that appropriate in this case. The flushing rate of the ponded area of the McQuesten wetland complex is high, therefore the inlet and outlet samples are believed to be adequately representative of the larger water body.

Total Phosphorus

Total phosphorus concentrations in the pond ranged from 0.025 to 0.082 mg/L, averaging 0.044 mg/L. Intlet TP concentrations were lower ranging from 0.01 to 0.015 and averaging 0.013 mg/L. Outlet TP concentrations ranged from .028 to .040 mg/L. The differences between inlet and outlet concentrations seem to suggest internal phosphorus loading originating from inputs from the commercial business strip directly adjacent to the east side McQuesten Pond on Second Street and large amounts of organic debris present in the pond.

Conductivity

In-pond conductivity was high at 579 uMhos/cm. Outlet conductivity levels were similar at 562 uMhos/cm.

pH and Acid Neutralizing Capacity

McQuesten Pond had a slightly elevated pH at 8.1. This high pH reading may reflect the fact that pH rises in productive, algae rich water bodies. Acid neutralizing capacity was also relatively high at 30.3 mg/L of CaCO.

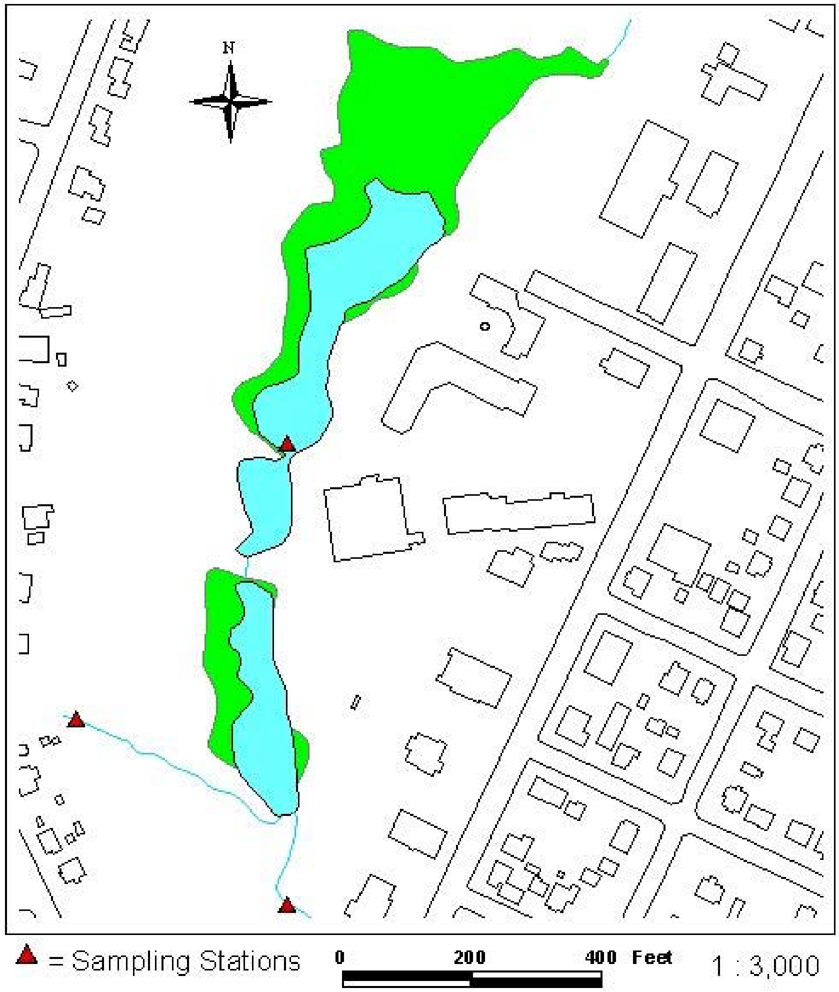
Turbidity

Turbidity was very high at 8.1 (NTU). Outlet turbidity was measured at 1.71 (NTU).

Overall Water Quality

McQuesten Pond is in essence, little more than a flooded wetland. It is highly biologically productive partly because of its shallow depth and rich sources of organic debris. Therefore, it is realistically inappropriate to compare this water body to other typical New Hampshire lakes and ponds.

Figure 4 – McQuesten Pond Sampling Stations



Vegetation Inventory

A vegetation inventory was conducted at McQuesten Pond on August 3, 2001. The following is a list of exotic plant species found at McQuesten Pond. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

Emergent

- Common Reed *(Phragmites communis)**
- Purple Loosestrife *(Lythrum salicaria)**

Upland Shrub

- Autumn Olive *(Elaegnus angustifolia)**
- European Buckthorn *(Rhamnus frangula*)*
- Japanese Knotweed *(Polygonum cuspidatum)**
- Rugosa Rose *(Rosa rugosa)**

Upland Tree

- Black Locust *(Robina pseudoacacia)**

Invasive plant species are a significant ecological issue at McQuesten Pond. The wetland areas are dominated by purple loosestrife and common reed.

Current Status

Unlike Manchester's other urban ponds, McQuesten Pond is privately owned by six individual abutters. Before any restoration activities or site improvements can take place here, easements or public ownership must be established to ensure the long-term success of restoration efforts.

Recently, the owner of the largest portion of the pond has made it known that he wishes to donate most of his property to the City for conservation. MCC and the UPRP will continue to pursue acquiring these important pieces of property for the future restoration of a healthy McQuesten Pond and wetland.

Plans for a wetlands boardwalk to enhance educational potential of this unique site are underway. The boardwalk will be located in the northern most part of the wetland, on City owned property.

Nutts Pond

Dissolved Oxygen

Nutts Pond, is over 9 meters deep, and was stratified before sampling began in April of 2001. Each sampling session identified a clearly defined epilimnion, metalimnion, and hypolimnion. Dissolved oxygen was almost nonexistent in the lowest depths of Nutts Pond, regularly measuring as low as 1.0% DO saturation. These kinds of anoxic conditions preclude the existence of most aquatic life in these areas.

Total Phosphorus

The hypolimnion held the highest concentrations of phosphorus ranging from 0.030 to 0.154 mg/L and averaging 0.097 mg/L. These are by far the highest TP concentrations of any Manchester pond. This is likely due to runoff from surrounding commercial and recreational areas and internal loading. Epilimnion TP values ranged from 0.015 to 0.041 mg/L and averaged 0.023 mg/L. This is slightly higher than 2000 levels when the epilimnion TP average was 0.017 mg/L.

Conductivity

Conductivity levels were very high, especially in the hypolimnion, where readings ranged from 1779 to 2090 uMhos/cm, and averaged 1960 uMhos/cm. This is related to metals contamination in the water column. The most significant metals found were iron (58.3 mg/L) and sodium (319.0 mg/L) in the hypolimnion in 2000. Epilimnion conductivity ranged from 519 to 1015 uMhos/cm, and averaged 714 uMhos/cm. This is a significant increase since 2000 when epilimnion conductivity averaged 485 uMhos/cm, an increase of 30%.

Chlorophyll-a

Composite chlorophyll *a* concentrations for the upper metalimnion and epilimnion ranged from 3.84 to 35.26 mg/m^3 and averaged 14.01 mg/m^3. This is a decrease of 44% since 2000, but this is still a high concentration considering the "typical" value for a NH lake is 3.9 mg/m^3.

Transparency

Secchi disk transparency and chlorophyll *a* content appeared to be related. When chlorophyll *a* was high, transparency was low. Transparency ranged from 0.7 to 3.85 meters, and averaged 2.4 meters. This is a decrease of 23% since 2000.

pH and Acid Neutralizing Capacity

Nutts Pond pH values ranged from 6.61 to 7.0 and averaged 6.82. This is within the range considered ideal for freshwater ecosystems. The ANC values varied very little, ranging from 13.8 to 20.0 mg of CaCO/L and averaging 17.3 mg/L.

Turbidity

Turbidity was high in Nutts Pond, especially in the hypolimnion where values ranged from 6.0 to 57.0 (NTU) and averaged 31.4 (NTU). Epilimnion turbidity values were much lower, averaging 1.76 (NTU). The high turbidity in the hypolimnion may be due to metals contamination. Turbidity readings in 2001 were similar to those of 2000.

Overall Water Quality

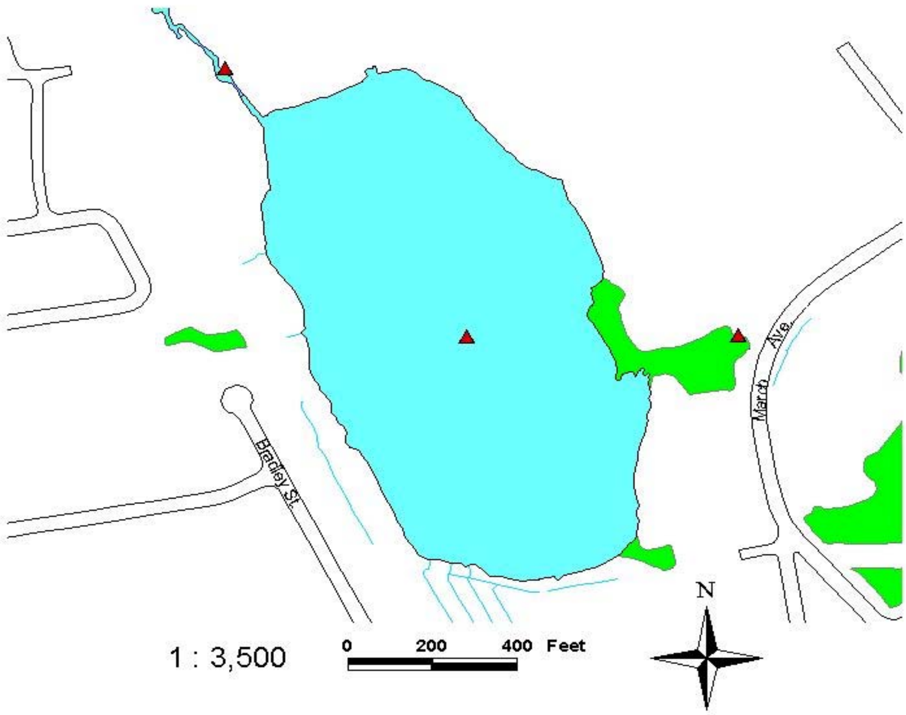
Nutts Pond is a repository for large amounts of untreated urban runoff. Its watershed consists of strip malls, industrial lots, streets, and residential neighborhoods. Runoff to Nutts Pond receives little to no treatment. Since heavy development began in the area approximately 30 years ago, sediment and pollution has been accumulating in stormwater created deltas at four points in the pond. The pond has high levels of heavy metals in the water column and is heavily influenced by ground water. At this point it remains unknown if the metals found in the water column (particularly iron) are derived from groundwater or other possible sources (such as accumulated debris in the pond or street runoff). Nutts Pond has shown steady decline in water quality over the last twenty years.

Table 6[1]
Comparison of Nutts Pond – 1981*, 1995, 2000 & 2001**

			2000		2001	
Parameter	1981	1995	Mean	Median	Mean	Median
pH	7.1	8.9	6.77	6.79	6.82	6.83
Alkalinity (mg/L)	12.0	15.8	13.9	14.1	17.3	17.0
Total phosphorus (mg/L)	.025	.025	.015	.013	.023	.019
Conductivity (uMhos/cm)	194	567	488	454	714.2	630.5
Secchi disk (m)	2.5	2.5	3.1	3.3	2.4	2.6

1) All values are epilimnetic.
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.
** NH Dept. of Environmental Services. 1996. Lake Trophic Data.

Figure 5 – Nutts Pond Sampling Stations



Vegetation Inventory

A vegetation inventory was conducted at Nutts Pond on August 10, 2001. The following is a list of exotic plant species found at Nutts Pond. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

Emergent

- Purple Loosestrife *(Lythrum salicaria)**

Submerged

- Brazilian Elodea *(Egaria densa)* * Confirmed by APS/BE @ DES on 8/22/01

Upland Shrub

- Autumn olive *(Elaegnus umbellate)**
- European Buckthorn *(Rhamnus frangula)**

Brazilian Elodea was confirmed in Nutts Pond in 2001. This is the first confirmed occurrence of this invasive aquatic plant in New England. DES and UPRP will be monitoring its growth and distribution patterns and developing a long-term management plan.

Fish Sample Analysis

Nutts Pond largemouth bass tissue sample analysis found chromium, copper, manganese, selenium, zinc and mercury. None of these metals were found in high enough concentrations to constitute a health risk to humans. No other contaminants tested were found above detectable limits. Fish data tables are included in Appendix A.

Sediment Sample Analysis

Nutts Pond sediment core samples contained high levels of several metals. Arsenic, chromium, copper, lead, mercury, and zinc were found to be exceeding the "severe effects level" criteria for aquatic organisms. The pesticide DDT and its chemical constituent p,p'-DDE were also found to exceed the "lowest effects level" criteria for aquatic organisms. Several PAH compounds were also found in Nutts Pond sediments. Anthracene, Benzo(a)anthracene, Benzo(b)flouranthene, Benzo(k)flouranthene, Benzo(ghi)perylene, Chrysene, Dibenzo(a,h)anthracene, Flouranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, and Pyrene were all found in levels exceeding the "lowest effects level" criteria for aquatic organisms. Sediment data tables are included in Appendix B.

Current Status

Many challenges face Nutts pond. In order to successfully restore the pond and adjacent public lands to their once popular and enjoyable conditions, a strong partnership must be developed between the UPRP, the Manchester Parks, Recreation and Cemetery Department and neighborhood activist groups. There is strong interest in redeveloping the rail corridor on the pond's east side into an alternative transportation trail. There is also interest in improving the ballpark and parking areas on the north side. Through a collaborative effort, a master plan can be developed which would incorporate water quality improvements and recreational enhancements around all sides of the pond. This plan would be based on long-term goals.

A project is currently underway to improve the tributary channel on the east side of the pond, stabilize an incidental beach on the east side and clean up debris in and around the outlet. This project is being done through a mitigation agreement between the Manchester Conservation Commission and an developer, related to a new residential development in Manchester.

Pine Island Pond

Pine Island Pond is the terminus of flow for a very large watershed; the Great Cohas Brook watershed. More than just immediate water quality data is required to understand the condition of Pine Island Pond. This waterbody in particular has the potential to change very quickly with changes in the watershed. Close and careful monitoring is essential to the future health of Pine Island Pond.

Dissolved Oxygen

Dissolved oxygen concentrations were highly variable throughout the monitoring season. Thermal stratification was evident when monitoring began in May. The lowest DO readings were recorded in August and isothermic conditions returned by the October monitoring session.

Total Phosphorus

Pine Island Pond total phosphorus readings were relatively uniform throughout the water column, with the epilimnion averaging .016 mg/L, metalimnion averaging .024 mg/L and hypolimnion averaging .030 mg/L. These values are lower than those recorded in 2000 with the exception of the 2001 hypolimnion TP value.

Conductivity

Conductivity values were also relatively uniform throughout the water column. The epilimnion averaged 383.3 uMhos/cm. The metalimnion averaged 410.0 uMhos/cm. The hypolimnion averaged 350.0 uMhos/cm. Surprisingly, epilimnion conductivity was higher than that in the hypolimnion. All conductivity values are quite high, possibly due to inputs from Cohas Brook upstream or proximity to the Manchester airport.

Chlorophyll-*a*

Composite chlorophyll *a* concentrations for the upper metalimnion and epilimnion ranged from 7.68 to 22.38 mg/m^3 with an average of 13.20 mg/m^3. This is an increase of 39% from 2000.

Transparency

Surprisingly, secchi disk transparency appeared to be improved instead of impeded by higher chlorophyll *a* content. As chlorophyll *a* increased, Secchi disk transparency also increased. Transparency ranged from 1.65 to 2.4 meters and averaged 1.9 meters at a total pond depth of 4.5 meters.

pH and Acid Neutralizing Capacity

Pine Island Pond pH values ranged from 6.86 to 7.20 and averaged 6.995. As would be expected, this is similar to pH values in 2000. ANC values ranged from 13.0 to 25.2, peaking in October, and averaging 20.1 mg of CaCO/L. These readings indicate that Pine Island Pond has substantial buffering capacity. These reading are also slightly higher than those found in 2000.

Turbidity

Turbidity ranged from 1.80 to 11.30 (NTU) in the hypolimnion and averaged 6.37 (NTU). Epilimnion turbidity ranged from 0.95 to 2.70 (NTU) and metalimnion turbidity ranged from 1.80 to 4.50 (NTU). The peak turbidity was recorded in August, coinciding with high chlorophyll *a* and TP readings. 2001 turbidity readings were significantly higher than those found in 2000.

Overall Water Quality

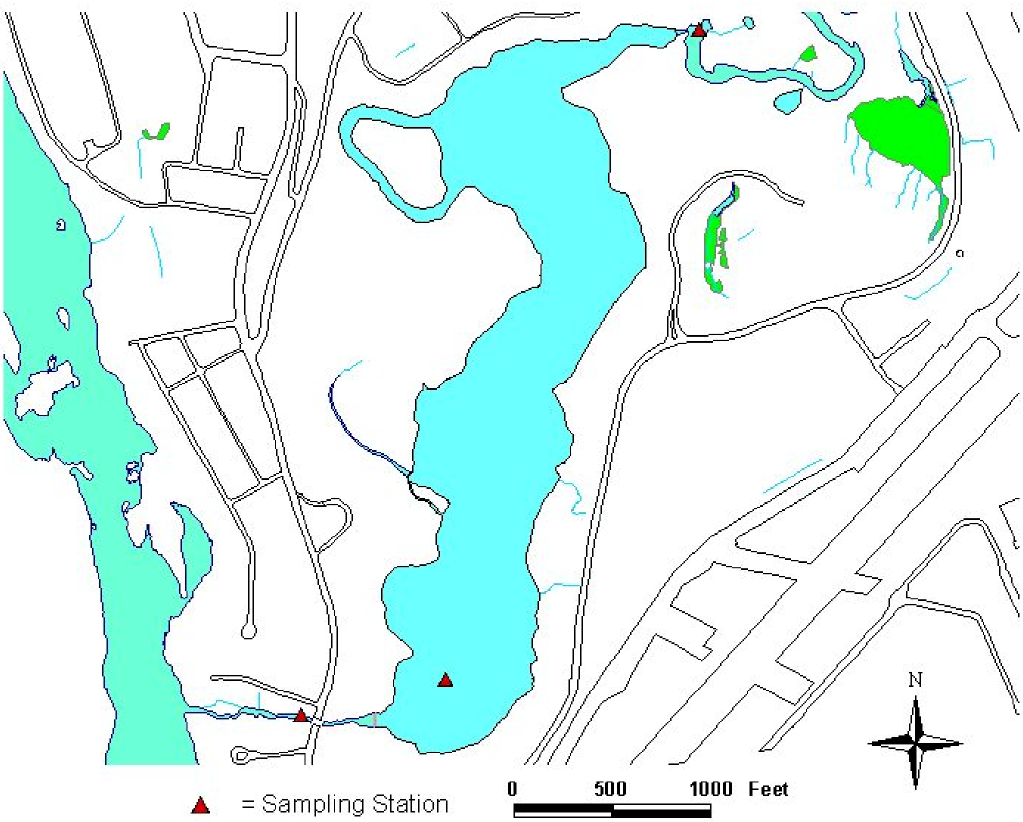
Pine Island Pond water quality is still relatively good. It is still used for swimming, fishing and boating. Twenty years of increasing watershed development have impacted the pond, however. Pine Island Pond has seen a slow but steady decline in water quality over the past twenty years.

Table 7[1]
Comparison of Pine Island Pond – 1980*, 1997, 2000 & 2001**

Parameter	8/5/1980	7/24/1997	2000 Mean	2000 Median	2001 Mean	2001 Median
pH	7.1	7.2	6.97	7.07	7.00	7.04
Alkalinity (mg/L)	15.2	20.6	17.1	19.5	20.1	21.0
Total phosphorus (mg/L)	.015	.018	.024	.024	.016	.017
Conductivity (uMhos/cm)	142.8	290.4	287.1	308	383.3	412.5
Secchi disk (m)	2.0	1.4	1.9	1.9	1.9	1.7

1) All values are epilimnetic.
* NH Dept. of Environmental Services. 1980. Trophic Classification of NH Lakes and Pond.
** NH Dept. of Environmental Services. 1998. Lake Trophic Data.

Figure 6 – Pine Island Pond Sampling Station



Vegetation Inventory

A vegetation inventory was conducted at Pine Island Pond on September 12, 2001. The following is a list of exotic plant species found at Pine Island Pond. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

<u>Emergent</u>

- Purple Loosestrife *(Lythrum salicaria)**

<u>Upland Herb</u>

- Climbing Bittersweet *(Celastrus orbiculata)**
- Japanese Knotweed *(Polygonum cuspidatum)**
- Rugosa Rose *(Rosa rugosa)**

<u>Upland Tree</u>

- Black Locust *(Robina pseudoacacia)**

Fish Sample Analysis

Pine Island Pond largemouth bass tissue sample analysis found chromium, manganese, selenium, zinc and mercury. None of these metals were found in high enough concentrations to constitute a health risk to humans, with the exception of mercury. Consumption of fish caught at Pine Island Pond could be a risk to human health, particularly in women and children. No other contaminants tested were found above detectable limits. Fish data tables are included in Appendix A.

Sediment Sample Analysis

Pine Island Pond sediment core samples showed elevated levels of chromiun, copper, lead, manganese, mercury, nickel and zinc. All of these metals exceeded the "lowest effects level" but not the "severe effects level" criteria for aquatic organisms. The pesticide DDT constituent, p,p'-DDE also exceed the "lowest effects level" for aquatic organisms. Sediment data tables are included in Appendix B.

Current Status

The Pine Island Pond watershed is under increasing threat of development by airport and other commercial interests. A resident pond advocacy group is key to increasing awareness and encouraging environmentally sensitive development in this area. A dedicated group of pond area residents have recently shown an interest in forming such a group. Steps are currently being taken to create a "Pine Island Pond Association" that will work toward the conservation and improvement of Pine Island Pond. At a public meeting held in February 2002, the formation of a pond association was discussed and plans are currently moving forward to establish a non-profit conservation group.

Stevens Pond

For more than 30 years, Stevens Pond has been impacted by untreated highway runoff from Interstate 93. Deicing activities and automotive byproducts have led to the serious degradation of a popular fishing and swimming spot in Manchester. Increasing development in the watershed is also an issue of concern.

Dissolved Oxygen

Pronounced stratification was observed at Stevens Pond when monitoring began in May. Dissolved oxygen saturation was already down to 0.10 mg/L at 5 meters of depth (or 1.0% saturation) in early May. This was the lowest DO reading recorded all season. May and June experienced super-saturation of dissolved oxygen in the metalimnion. DO saturation began leveling off through the water column in late September, but still remained critically low near the bottom even after thermal stratification was no longer evident.

Total Phosphorus

Total phosphorus levels in the hypolimnion ranged from .018 to .029 with an average of .023 mg/L. This is approximately 90% lower than 2000 hypolimnion TP levels. High TP levels in the hypolimnion may indicate internal loading. Epilimnion TP levels ranged from .009 to .040 with an average of .025 mg/L. This is an increase of approximately 25% since 2000.

Conductivity

Conductivity levels remained relatively constant throughout the season and throughout the water column with peak conductivity occurring in May. Epilimnion conductivity ranged from 981 to 1376 and averaged 1148.8 uMhos/cm. This is an increase of approximately 49% since 2000. Metalimnion conductivity ranged from 940 to 1368 and averaged 1123.0 uMhos/cm. Hypolimnion conductivity ranged from 1128 to 2220 and averaged 1633.5 uMhos/cm. Hypolimnion conductivity increased by approximately 106% since 2000. These are very high readings, most likely caused by highway runoff from I-93.

Chlorophyll-*a*

Composite chlorophyll *a* concentrations for the upper metalimnion and epilimnion ranged from 2.35 to 13.94 and averaged 6.26 mg/m^3. This is an approximate 28% reduction since 2000.

Transparency

Secchi disk readings ranged from 2.1 to 3.4 and averaged 2.5 meters. Transparency did not appear to be directly affected by chlorophyll *a* content.

pH and Acid Neutralizing Capacity

Stevens Pond pH ranged from 6.93 to 7.24 and averaged 7.14. There was no significant change in pH between 2000 and 2001. ANC values ranged 24.1 to 37.6 mg/L of CaCO. ANC averaged 31.0 mg/L of CaCO. Stevens Pond has a high buffering capacity. There was no significant change in ANC between 2000 and 2001.

Turbidity

Stevens Pond turbidity values were highest in the hypolimnion. This may be caused by high levels of sodium and chloride in the bottom sediments from highway runoff. Hypolimnion turbidity ranged from 1.6 to 4.3 with an average of 2.65 (NTU). Epilimnion and metalimnion turbidity values averaged 2.23 and 1.75 respectively.

Overall Water Quality

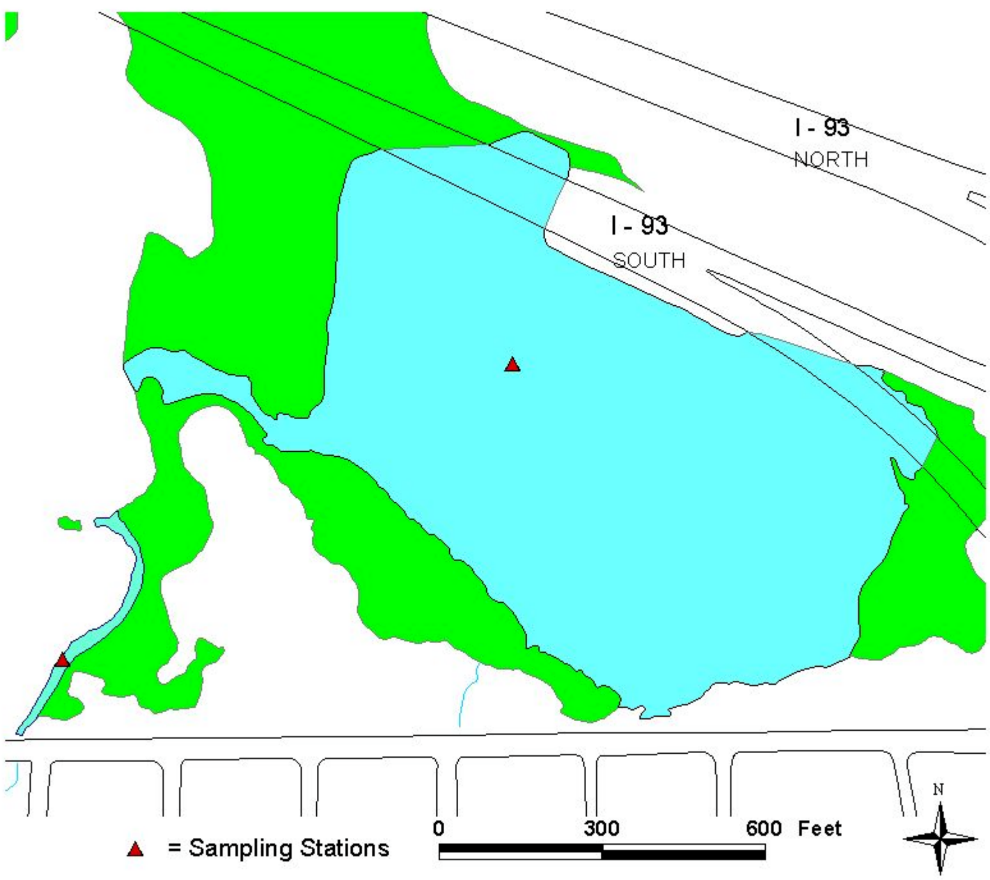
Stevens Pond has been severely impacted by development. Eutrophication is being accelerated by highway runoff. Chloride and sodium levels are among the highest ever recorded in a freshwater body in New Hampshire. Significant decline cannot be seen over the past twenty years, with the exception of conductivity levels. Stevens Pond accelerated eutrophication apparently began before documentation of conditions in 1981.

Table 8[1]
Comparison of Stevens Pond – 1981*, 1997, 2000 & 2001**

Parameter	7/29/1981	7/23/1997	2000 Mean	2000 Median	2001 Mean	2001 Median
pH	7.2	7.7	7.11	7.15	7.14	7.20
Alkalinity (mg/L)	33.0	31.8	34.2	34.8	31.0	32.7
Total phosphorus (mg/L)	.028	.028	.019	.019	.025	.028
Conductivity (uMhos/cm)	301	696	769	765.5	1148.8	1128.0
Secchi disk (m)	2.0	1.3	2.6	2.6	2.5	2.6

1) All values are epilimnetic.
* NH Dept. of Environmental Services. 1981. Trophic Classification of NH Lakes and Ponds.
** NH Dept. of Environmental Services. 1998. Lake Trophic Data.

Figure 7 – Stevens Pond Sampling Stations



Vegetation Inventory

A vegetation inventory was conducted at Stevens Pond on August 10, 2001. The following is a list of exotic plant species found at Stevens Pond. Exotic species represent a threat to the ecological integrity of a pond ecosystem. A complete native plant inventory list is included in Appendix C.

Emergent

- Common Reed *(Phragmites communis)**
- Purple Loosestrife *(Lythrum salicaria)**

Upland Shrub

- European Burkthorn *(Rhamnus frangula)**

The Stevens Pond littoral zone and adjacent wetlands are dominated by purple loosestrife and common reed.

Sediment Sample Analysis

Stevens Pond sediment core samples showed elevated levels of cadmium, chromiun, copper, lead, manganese, mercury, nickel and zinc. All of these metals exceeded the "lowest effects level" and copper and zinc exceeded the "severe effects level" criteria for aquatic organisms. The pesticide DDT constituent, p,p'-DDE also exceed the "lowest effects level" for aquatic organisms. The PAH compound Pyrene also exceeded the "lowest effects level" criteria. Sediment data tables are included in Appendix B.

Current Status

Stevens Pond is a highly impacted waterbody and is important to recognize the benefits and necessity of multi-agency collaboration to reach restoration goals. Several agencies have already begun working together to formulate a solution to the issue of untreated, nutrient and chloride rich runoff from the I-93 overpasses. The NH Department of Transportation has expressed willingness to work with DES and the UPRP to treat the highway runoff that is so drastically affecting the health of Stevens Pond. Proposed solutions include a closed drainage system to divert stormwater to where adequate treatment can be attained, or a berm diversion system to separate the stormwater from Stevens Pond. A feasibility study to better understand the extent of the problem and develop proposed solutions may be performed during 2002.

Section III.
Short and Long Term Changes

Short Term Changes

Manchester's urban ponds experienced drastic fluctuations in weather over the past two years, as did the whole Northeast. Weather conditions directly impact water quality, especially where small urban water bodies are concerned. Certain parameters are susceptible to quick increases or decreases in pollutant concentration depending on precipitation. This can be seen in the water quality data sets for some of Manchester's ponds.

The 2000 data set shows different conditions compared to the 2001 data. The winter of 2000/01 substantial snowfall late in the season. When this snowpack melted, the nutrients and other pollutants which had been tied up were released all at once. This may explain the pollutant spikes observed in the earliest samples collected in 2001. Due to the drought of 2001, the ponds experienced less flushing through the summer season, possibly allowing nutrients to accumulate. Under normal precipitation conditions, this would have been flushed downstream. Average total phosphorus increased at four of six ponds. Conductivity increased at all ponds, and chlorophyll *a* increased at three of six ponds. Secchi disk transparency decreased or was unchanged at four of six ponds. Conductivity levels doubled at Nutts and Stevens Ponds. This amount of apparent degradation in one year would be very alarming had 2001 been a more typical year. Table 8 compares water quality values at the ponds over the past two years.

Table 9
Comparison of 2000 & 2001
Manchester Pond Averages*

	Dorrs Pond		Maxwell Pond		Nutts Pond		Pine Island Pond		Stevens Pond		Crystal Lake	
Parameter	**2000**	**2001**	**2000**	**2001**	**2000**	**2001**	**2000**	**2001**	**2000**	**2001**	**2000**	**2001**
pH	7.08	7.15	6.54	6.63	6.77	6.82	6.97	7.00	7.11	7.14	6.99	7.09
Alkalinity (mg/L)	6.2	21.7	6.8	9.8	13.9	17.3	17.1	20.1	34.2	31.0	18.1	17.3
Total phosphorus (mg/L)	.045	.024	.014	.018	.015	.023	.024	.016	.019	.025	.011	.012
Conductivity (uMhos/cm)	408	831.3	121.8	154.6	488	714.2	287.1	383.3	769	1148.8	418.7	439.7
Secchi disk (M)	1.1	1.3	>1.1	>1.1	3.2	2.4	1.9	1.9	2.6	2.5	4.3	3.5
Chlorophyll *a* (mg/m^3)	30.84	14.75	1.55	3.17	27.42	14.01	8.04	13.20	8.68	6.26	3.39	4.75

* Values are epilimnetic mean values.

Long Term Trends

Two years or data are not sufficient to begin tracking any long-term trends. However, some historic data exists for some ponds that have been collected over the last twenty years. Scientific data is not required though, to demonstrate that Manchester's ponds are being degraded. Manchester residents will readily testify to swimming at Nutts, Dorrs and Stevens Ponds when they were younger. These ponds are now choked with algal blooms and filled with debris.

In some cases, water quality was already significantly degraded when measurements were first recorded. For example, in 1981, Nutts and Stevens Pond had elevated levels of total phosphorus and conductivity and shallow secchi depths. By this time, most of these ponds had been receiving untreated urban runoff for several years. Conductivity has doubled at many locations over the last twenty years and in some cases, total phosphorus has shown a sharp increase. However, water quality at other Manchester urban ponds has not changed greatly since baseline data was collected in the early 1980's. These ponds do not seem to be affected by the regional problem of acidification. pH has not drastically changed in the last twenty years presumably due to ponds' high acid neutralizing capacities.

Section IV.
Water Quality Improvement Projects

The ultimate purpose of UPRP is to improve water quality to the greatest extent practicable at each pond. To do this, a number of water quality improvement projects will be undertaken. Determining the most logical and cost effective course to proceed is based on prioritizing identified projects. Prioritization of locations and projects has been based on factors such as public interest, current and potential public use, ease with which restoration can be accomplished, and the likelihood of showing short-term results. Over the next three years, the projects listed in Table 10, as well as others, will be completed, to the extent that resources allow.

Table 10 shows specific pond goals, prioritized improvement opportunities and other opportunities (educational, recreational, and preservation) associated with each pond.

Other Activities

Over the past two years, many other activities and events have taken place to further the cause of pond conservation. Education and public outreach is large part of the program. Several pond watershed community meetings have been held to raise awareness of the UPRP and obtain public input. As a result, a new pond association will soon be formed: The Pine Island Pond Association. Pond meetings consist of an introduction to the UPRP, past accomplishments, future endeavors, and a public brainstorming session to better understand what watershed residents feel is important. Educational and outreach materials are included in Appendix F.

The UPRP also held the first “Manchester Ponds Day and Earth Day Event” in 2001. This was a major educational event featuring over 20 environmental organizations and children’s activities. Approximately 70 environmental professionals and other volunteers teamed up to make the day a great success. Clowns, face painting, kayak demonstrations, alternative fuel vehicles, live entertainment, environmental and political speakers and informational booths, nature walks, and scavenger hunts were enjoyed by approximately 1,000 individuals. The second annual “Manchester Earth and Ponds Festival” is scheduled for June 22, 2002.

Trash clean up events have been organized at each of the ponds over the past two years as well. Each spring, volunteers are recruited to clean up trash and other debris around the pond shorelines and shallow water areas. Much of the shoreline and riparian areas surrounding the ponds are heavily used. Because of this, large amounts of litter accumulate in these areas. Each clean up date results in several trash bags of litter being collected and any number of various pieces of larger debris and garbage, such as tires, furniture, wood and metal debris. There have been 14 pond clean up days over the past two years.

Pond Name	**Pond Goal(s)**	**WQ Improvement Opportunities (Prioritized)**	**Outreach/ Education Opportunities**	**Recreational Opportunities**	**Land Preservation Opportunities**	**Other**
Crystal Lake	-Maintain swimmable/fishable water quality standards	**(1) - Beach parking lot runoff/drainage improvements** **(2)** - Phrag. Chem./mechanical treatment **(3)** -Corning Rd runoff/drainage improvements - StormTreat system maintenance	- Planting workshop - Intensely maintained shoreline - Phragmites education - Milfoil prevention	-Beach use restrictions/parking stickers	-Land development pressure -Land acquisition	-Watershed Management Plan
Dorrs Pond	-Restore fishable/swimmable water quality standards	**(1) -Trib 2East runoff/drainage** **(2)** -DP3 trib drainage **(3)** – Wetland function study (north end) - Sediment dredging (north end) - Goldfish Pond drainage (Hooksett) - De-channelize Ray Brook	- Duck feeding - Bonneville & Son swale - Invasive species - Debris at dam - Kiosk - Fertilizer education	-P&R trail/parking lot	- Land development pressure - Secure parkland - Town Forest designation	
McQuesten Pond	-Secure property easements/ownership	**(1) - Secure property easements/ ownership** - Pavement reduction - Shoreline restoration	-Build kiosk -Invasive species -Duck feeding -Dumpster & lot runoff -Pavement reduction -Shoreline restoration	-Boardwalk at North end	-Private property: secure conservation easements	
Maxwell Pond	-Assess feasibility of dam removal -Habitat assessment/enhancement	**(1) - Dam removal study** **(2)** - Upstream sedimentation **(3)** -Apt. complex runoff/drainage - Dredging	-Build kiosk -Cemetery debris -Invasive species	-Create car-top boat-launch - Park improvements (P&R)	-Secure parkland -Research easements and zoning	
Nutts Pond	-Improve sport fishing and non-motorized/recreational boating opportunities - Improve water quality	**(1) -Urban runoff at 4 outfalls/drainage study** -Dredging near outfalls -East side outfall -Shoreline stabilization/plantings	- "Save Nutts Pond" campaign - S.Willow St commercial lot maintenance -Debris -Invasive species	-Pond circuit trail -Boat ramp improvements - Rails to Trails Project		-Diagnostic & Feasibility Study
Pine Island Pond	-Maintain fishable/swimmable water quality standards -Improve fish habitat	-Sedimentation at North end -Accelerated plant growth -Streambank stabilization at Cohas	-Accelerated plant growth - Invasive species - Boating - Fertilizer education	**(1) -Fish passage at dam**		-Watershed Management Plan
Stevens Pond	-Improve water quality through partnership with DOT	**(1) -I-93 Runoff** (NH DOT) - Headwaters erosion	-Invasive species - Kiosk	**(1) -Boat launch improvement, wetlands boardwalk, trail creation/ improvement**	-Secure parkland	

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New Hampshire Volunteer Lake Assessment Program. 1999. Annual Report for Crystal Lake Manchester. NH DES, Water Division, Biology Bureau, Concord, NH.

APPENDIX A

Fish Sampling Data

APPENDIX B

Sediment Sampling Data

APPENDIX C

Vegetation Inventory Data

Vegetation Inventories

Crystal Lake – native species
Inventoried on 8/24/2001 by Jen Drociak of the Manchester Conservation Commission

Emergent
Arrow Arum *(Peltandra virginica)*
Arrowhead/Duck Potato *(Sagitaria latifolia)*
Bulrush *(Scirpus spp.)*
Burreed *(Sparganium eurycarpum)*
Cattail *(Typha latifolia)*
Pickerelweed *(Pontedaria cordata)*
Pipewort *(Eriochaulon compressum)*
Quillwort *(Isoetes lacustrus)*

Floating
Duckweed *(Lemna spp.)*
Floating Heart
Pondweed *(Pontamegeton perfoliatus)*
White Water Lily *(Nymphaea ororata)*
Yellow Pond Lily *(Lythrum salicaria)*

Submerged
Bladderwort *(Utricularia vulgaris)*
Bushy Pondweed/Naiad *(Najas flexilis)*
Stonewort *(Nitella spp.)*

Wetland Herb
American Cranberry *(Vaccinium macrocarpon)*
Boneset *(Eupatorium perfolatum)*
Cinnamon Fern *(Osmunda cinnamomea)*
Jewelweed *(Impatiens capensis)*
Meadowsweet *(Spiraea latifolia)*
Marsh St. Johnswort *(Hyperisum virginicum)*
Mint *(Lycopus genus)*
Royal Fern *(Osmunda regalis)*
Sedge *(Carex spp.)*
Sensitive Fern *(Onoclaea sensibilis)*
Swamp Loosestrife *(Decodon verticillatus)*
Steeplebush *(Spiraea tomentosa)*
Sphagnum Moss
Three-Way Sedge *(Dulichium arundinaceum)*
Water Hemlock *(Circuta malculata)*
Water Horsetail *(Esquisitum fluviatile)*
Water Plantain *(Alisma plantago)*

Wetland Shrub
Highbush Blueberry *Vaccinium spp.)*
Leatherleaf *(Chamaedaphne calyculata)*
Sepckled Alder *(Alnus rugosa)*
Red Osier Dogwood *(Cornus stolinifera)*

Wetland Tree
Red Maple *(Acer rubrum)*
Silver Maple *(Acer sacharrinium)*

Upland Herb
Canada Mayflower *(Maianthemum canadense)*
Mountain Laurel

Upland Tree
Black Cherry *(Prunus serotina)*
Eastern White Pine *(Pinus strobus)*
Gray Birch *(Betula populifolia)*
Quaking Aspen *(Populus tremuloides)*
Red Oak *(Quercus rubrum)*
Tamarack/Larch *(Larix laricina)*

Dorrs Pond – native plant species

Inventoried on 8/3/2001 by Jen Drociak of the Manchester Conservation Commission.

Emergent

Arrowhead/Duck-potato *(Sagitaria latifolia)*
Cattail *(Typha latifolia)*
Great bulrush *(Scirpus validus)*
Pickerelweed *(Pontedaria cordata)*

Floating

Duckweed *(Lemna spp.)*
Watershield *(Brasenia schreberi)*
White Water Lily *(Nymphaea ororata)*
Yellow Pond Lily *(Nuphar spp.)*

Submerged

Bladderwart *(Utricularia vulgaris)*
Bushy Pondweed/Naiad *(Najas flexilis)*
Coontail *(Ceratophyllum demersum)*
Waterweed *(Elodea canadensis)*

Wetland Herb

Jewelweed *(Impatiens capensis)*
Marsh St. Johnswort *(Hyperisum virginicum)*
Sedge *(Carex spp.)*
Skunk Cabbage *(Symplocarpus foetidus)*
Water Hemlock *(Cicuta malculata)*

Wetland Shrub

Elderberry *(Sambucus canadensis)*
Northern Arrowwood *(Viburnum recognitum)*
Speckled Alder *(Alnus rugosa)*
Sweet Gale *(Myrica gale)*
Sweet Pepperbush *(Clethra alnifolia)*

Wetland Tree

Red Maple *(Acer rubrum)*

Upland Shrub

Blackberry *(Rubus angustifolium)*
Lowbush Blueberry *(Vaccinium angustifolia)*
Raspberry *(Rubus idaeus)*

Upland Tree

American Elm *(Ulmus Americana)*
American Mountain Ash *(Sorbus Americana)*
Black Cherry *(Prunus serotina)*
Black Locust *(Robina pseudoacacia)**
Eastern White Pine *(Pinus strobus)*
Northern Catalpa *(Catalpa bignoniodes)*
Quaking Aspen *(Populus tremuloides)*
Red Oak *(Quercus rubrum)*
Red Pine *(Pinus resinosa)*
Sassafras *(Sassafras albidum)*
White Birch *(Betula papyrifera)*
White Oak *(Quercus alba)*
Witchhazel *(Hamamelis virginiana)*

Groundcover

Canada Mayflower *(Maianthemum canadense)*
Goldthread/Canker root *(Coptis groenlandica)*
Partridgeberry *(Mitchella repens)*
Starflower *(Trientalis borealis)*
Teaberry/Wintergreen *(Gaultheria procumbens*

Maxwell Pond – native plant species

Inventoried on 8/3/2001 by Jen Drociak of the Manchester Conservation Commission

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Emergent

Arrowhead *(Sagitaria latifolia)*
Burreed *(Sparganium eurycarpum)*
Pickerelweed *(Pontederia cordata)*
Pipewort *(Eriocaulon septangulare)*

Floating

Floating Heart
Floating Pondweed *(Pontamogeton natans)*
Ribbon-Leaf Pondweed *(Pontamogeton epihydrus)*
Yellow Pond Lily *(Nuphar spp.)*

Submerged

Bladderwort *(Utricularia vulgaris)*
Bushy Pondweed/Naiad *(Najas flexilis)*

Wetland Herb

Blue Flag/Iris *(Iris versicolor)*
Cinnamon Fern *(Osmunda cinnamomea)*
Marsh St. Johnswort *(Hypericum virginicum)*
Meadowsweet *(Spiraea latifolia)*
Sedge *(Carex spp.)*
Sensitive Fern *(Onoclea sensibilis)*
Soft-Stemmed Bulrush *(Scirpus validus)*
Steeplebush *(Spiraea tomentosa)*
Three-Way Sedge *(Dulichium arundinaceum)*
Water Smartweed *(Polygonum amphibium)*
Water Hemlock *(Cicuta malculata)*

Wetland Shrub

Buttonbush *(Cephalanthus occidentalis)*
Northern Arrowwood *(Viburnum recognitum)*
Speckled Alder *(Alnus rugosa)*

Upland Shrub

Red-Osier Dogwood *(Cornus stolinifera)*

Upland Herb

Canada Mayflower *(Mainthemum canadense)*
Climbing Hempweed *(Mikania scandens)*
False Solomon's Seal *(Smilacina racemosa)*
Hay-Scented Fern *(Dennstaedtia punctilobulia)*
Milkweed *(Asclepias syriaca*)

McQuesten Pond – native plant species

Inventoried on 8/3/2001 by Jen Drociak of the Manchester Conservation Commission.

Emergent

Arrowhead/Duck-potato *(Sagitaria latifolia)*
Cattail *(Typha latifolia)*

Floating

Duckweed *(Lemna spp.)*

Wetland Shrub

Speckled Alder *(Alnus rugosa)*

Wetland Herb

Blue Vervain *(Verbena hastate)*
Jewelweed *(Impatiens capensis)*
Meadowsweet *(Spiraea latifolia)*

Wetland Tree

Red Maple *(Acer rubrum)*
Willow *(Salix spp.)*

Upland Herb

Common Mullein *(Verbascum thaspus)*
Nightshade *(Atropa belladonna)*
Queen Anne's Lace *(Daucus carota)*
Yarrow *(Achillea millefolium)*

Upland Tree

Ashed-Leaved Maple/Boxelder *(Acer negunda)*
Black Cherry *(Prunus serotina)*
Quaking Aspen *(Populus tremuloides)*
Sassafras *(Sassafras albidum)*
White Birch *(Betula papyrifera)*Canada Mayflower (Mainthemum canadense) Climbing Hempweed *(Mikania scandens)*

Nutts Pond – native plant species
Inventoried on 8/10/2001 by Jen Drociak of the Manchester Conservation Commission

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Emergent
Arrowhead/Duck-potato *(Sagitatia latifolia)*
Burreed *(Sparganium eurycarpum)*
Cattail *(Typha latifolia)*
Giant Bulrush *(Scirpus validus)*
Iris/Blue Flag *(Iris versicolor)*
Pickerelweed *(Pontedaria cordata)*

Floating
Floating-Leaved Pondweed *(Pontomageton natans)*
White Water Lily *(Nymphaea ororata)*
Yellow Pond Lily *(Nuphar spp.)*

Submerged
Bushy Pondweed *(Najas flexibilis)*
Waterweed *(Elodea canadensis)*

Wetland Herb
Jewelweed *(Impatiens capensis)*
Meadowsweet *(Spiraea latifolia)*
Royal Fern *(Osmunda regalis)*
Sweet Gale *(Myrica gale)*

Wetland Shrub
Buttonbush *(Cephalanthus occidentalis)*
Chokeberry *(Aronia spp.)*
Highbush Blueberry *(Vaccinium spp.)*
Northern Arrowwood *(Viburnum recognitum)*
Red-Osier Dogwood *(Cornus stolonifera)*
Speckled Alder *(Alnus rugosa)*

Wetland Tree
Red Maple *(Acer rubrum)*
Silver Maple *(Acer saccharinium)*
Willow *(Salix spp.)*

Upland Herb
Curly Dock *(Rumex crispus)*
Goldenrod *(Solidago spp.)*
Grape *(Vistis spp.)*
Milkweed *(Asciepias syrica)*
Oriental Bittersweet*(Celastrus orbiculata)**
Plantain *(Plantago major)*
Pokeweed *(Phytolacca Americana)*
Purple Vetch *(Vicia benghalensis)*
Queen Anne's Lace *(Daucus carota)*
Russian Sage *(Perovkia atriplicifolia)*
Timothy *(Phleum pratense)*
Virginia Creeper *(Parthenocisus quinquefolia)*

Upland Tree
Boxelder/Ash-Leaved Maple *(Acer negunda)*
Pin Oak *(Quercus palustris)*
Plane Tree *(Platanus spp.)*
Quaking Aspen *(Populus tremuloides)*
Red Pine *(Pinus resinosa)*
White Oak *(Quercus alba)*

<u>Pine Island Pond </u>– native plant species
Inventoried on 9/12/2001 by Jen Drociak of the Manchester Conservation Commission.

<u>Emergent</u>
Arrow Arum *(Peltandra virginica)*
Arrowhead/Duck Potato *(Sagitaria latifolia)*
Cattail *(Typha latifolia)*
Grass-Leaved Arrowhead (Sagitarria graminea)
Iris/Blue Flag *(Iris versicolor)*
Pickerelweed *(Pontederia cordata)*
Tapegrass *(Vallisenaria spp.)*

<u>Floating</u>
Duckweed *(Lemna spp.)*
White Pond Lily *(Nymphaea ororata)*

<u>Submerged</u>
Bladderwort *(Utricularia vulgaris)*
Bushy Pondweed/Naiad *(Najas flexilis)*
Coontail/Hornwort *(Ceratophyllum demersum)*
Floating-Leaf Pondweed *(Pontamogeton natans)*
Ribbon-Leaf Pondweed *(Pontamogeton ephihydrus)*
Common Waterweed *(Egaria densa)*

<u>Wetland Herb</u>
Blue Vervain *(Verbena hastate)*
Beak Rush *(Rhynchospora capitellata)*
Bog Hemp/False Nettle *(Boehmeria cylindrical)*
Boneset *(Eupatorium perfolatum)*
Cardinal Flower *(Lobelia cardinalis)*
Jewelweed/Spotted Touch-Me-Not *(Impatiens capensis)*
Marsh St. Johnswort *(Hyperisum virginicum)*
Meadowsweet *(Spiraea latifolia)*
Royal Fern *(Osmunda regalis)*
Sedge *(Carex spp.)*
Sensitive Fern *(Onoclea sensibilis)*
Soft-Stemmed Bulrush *(Scirpus validus)*
Swamp Milkweed *(Asclepias incarnata)*
Three-Way Sedge *(Dulichium arundinaceum)*
Umbrella Sedge *(Cyperus strigosus)*Water Horehond/Bugleweed *(Lycopus virginicus)*
Water Smartweed *(Polygonum amphibium)*

<u>Wetland Shrub</u>
Buttonbush *(Cephalanthus occidentalis)*
Silky Dogwood *(Cornus amomum)*
Sweet Pepperbush *(Clethra alnifolia)*

<u>Wetland Tree</u>
Red Maple *(Acer rubrum)*
Swamp Oak *(Quercus bicolor)*
Willow (*Salix spp.)*

<u>Upland Herb</u>
Bracken Fern *(Pteridium aquilirum*
Curly Dock *(Rumex crispus)*
Goldenrod *(Solidago spp.)*
Grape *(Vistis spp.)*
Ground Juniper *(Juniperis communis)*
Highbush Blueberry *(Vaccinium corumbosum)*
Purple Vetch *(Vicia benghalensis)*
Red Top
Sweet Fern *(Componia peregrina)*
Sumac *(Rhus spp.)*

<u>Upland Shrub</u>
Red Osier Dogwood *(Cornus stolonifera)*

<u>Upland Tree</u>
Eastern Hemlock *(Tsuga canadensis)*
Eastern White Pine *(Pinus strobus)*
Grey Birch *(Betula populifolia)*
Red Oak *(Quercus rubrum)*
White Oak *(Quercus alba)*

Stevens Pond – native plant species
Inventoried on 8/10/2001 by Jen Drociak of the Manchester Conservation Commission.

Emergent
Burreed *(Sparganium eurycarpum)*
Cattail *(Typha latifolia)*
Pickerelweed *(Pontederia cordata)*
Swamp Loosestrife *(Decodon verticillatus)*

Floating
Duckweed *(Lemna spp.)*
White Water Lily *(Nymphaea orodata)*
Yellow Pond Lily *(Nuphar spp.)*

Submerged
Bladderwort *(Utricularia vulgaris)*
Bushy Pondweed/Naiad *(Najas flexilis)*
Coontail *(Ceratophyllum demersum)*
Stonewort *(Nitella spp.)*
Waterweed *(Elodea Canadensis)*

Wetland Herb
Highbush Blueberry *(Vaccinium spp.)*
Jewelweed *(Impatiens capensis)*
Meadowsweet *(Spiraea latifolia)*

Wetland Shrub
Northern Arrowwood *(Viburnum recognitum)*
Sweet Gale *(Myrica gale)*

Wetland Tree
Red Maple *(Acer rubrum)*

Upland Herb
Butter & Eggs *(Linaria vulgaris)*
Common Mullein *(verbascum thaspus)*
Curly Dock *(Rumex crispus)*
Field Horsetail *(Esquisetum arvense)*
Lily of the Valley *(Convallaria majalis)*
Plantain *(Plantago major)*
Purple vetch *(Vicia benghalensis)*
Russian Sage *(Perovskia atriplicifolia)*
Thistle *(Cirsium spp.)*

Upland Tree
American Elm *(Ulmnus Americana)*
Black Cherry *(Prunus serotina)*
Crab Apple *(Malus coronaria)*
Eastern White Pine *(Pinus strobus)*
Red Oak *(Quercus rubra)*

APPENDIX D

Water Quality Sampling Procedure

<u>Manchester Urban Ponds Restoration Program</u>
Pond Sampling Procedure
(Based on NH VLAP Protocol)

1. All bottles must be labeled with: pond name, city, date, time, and sample description.

2. Locate the deepest spot in the pond using map provided. Drop anchor and verify with depth finder.

<u>Dissolved Oxygen/Temperature Profile</u>:

1. Inspect the probe membrane. No are bubbles should be present.
2. Turn the unit on (set knob to "calibrate"). The YSI 52 Meter will perform a self-check. Moisten the sponge in the cap on the DO probe. Reattach the cap leaving a small space between the sponge and the probe. Press confirm when prompted. Press confirm again when "Enter cal value Last = 100%" appears. The meter will indicate when calibration is complete.
3. Take surface reading (submerge the probe just under the water's surface). Record on data sheet.
4. Take readings at each meter to within 1 meter of the bottom. Record these on the data sheet.
5. Take note of temperature readings that differ by more than 1 degree celcius between meters. Once a significant temperature drop is observed, the temp. will continue to fall meter by meter until the temp. levels off. The first point where the temp. drops by 1 degree or more is the bottom of the top water layer (*epilimnion*). The point where the temp. levels off after steadily dropping is the bottom of the middle layer (*metalimnion* or *thermocline*). The bottom layer is the *hypolimnion*. Identify the midpoint depth of each layer and record this on the data sheet in the area labeled "sample depths".

<u>Kemmerer Bottle</u>:

1. Using the Kemmerer Bottle, collect samples from the midpoint of each water layer. These samples are placed in the large white (opaque) bottles. Be sure to rinse these bottles with pond water before filling. Also fill the small brown bottles using these samples (do not rinse these bottles; contain strong acid preservative).

2. <u>Composite Sample</u>:
   1. Rinse the bucket with lake water and discard over side of boat.
   2. Take one Kemm. Bottle sample at each meter beginning at the midpoint of the middle layer and working up to 1 meter. If the pond is not stratified, start at 2/3 of the pond depth and work up to 1 meter.
   3. Empty half of the Kemm. Bottle sample from each depth into the bucket and discard the rest. Mix well.
   4. Rinse the large brown bottle with water from the bucket and discard. Then fill the bottle to the top. Label the bottle "____M Comp" indicating the deepest point at which the composite was started.

<u>Plankton Sample</u>:

1. Collect a sample of plankton using the plankton net.
2. Be sure the clamp is closed at the net outlet. Lower the net to the midpoint of the middle layer and retrieve slowly and steadily. When net reaches the surface rinse the plankton down the sides by dipping the net repeated, being careful not to submerge completely.

3. Raise the net from the water and gently swirl it in a circular fashion to concentrate the plankton.
4. Empty the contents into one of the glass bottles by releasing the clamp on the hose at the bottom of the net. Close the clamp when finished.
5. Lower the bottom portion of the net into the water, raise and swirl again. Release the clamp and empty contents into the same glass bottle. This rinses remaining plankton off the net, and into the sample.
6. Repeat steps 2 through 5. This time add three drops of Lugall's solution (brown liquid in the small glass vial) to the second sample and slightly agitate the sample. The correct amount of Lugall's solution should make the sample tea-colored.
7. Label both glass bottles "____M Vert" indicating the depth at which you started the haul.

Secchi Disk:

1. Lower the secchi disk over the shady side of the boat until it disappears from sight.
2. Slowly raise the disk until the white is just visible. Note the depth at which this occurs. Record the average of these two points.
3. Repeat this process yourself, or by another monitor. Record both transparency readings on the Field Data Sheet, then calculate the average.

Inlet & Outlet Sample Collection:

1. At each designated inlet and outlet fill a large white bottle and a small brown bottle.
2. Label these bottles "______ Inlet", or "______ Outlet".
3. Be sure the water is flowing. Samples should not be taken from a stream that is stagnant. Be careful not to agitate the water upstream from where the sample is to be obtained.
4. Rinse the white bottle using stream water and discard rinse water downstream from sample location.
5. Collect sample by dipping the white bottle under the surface, being careful not to disturb the bottom.
6. Fill the small brown bottle to the neck with water from the white bottle. **Do not** rinse the small brown bottles.
7. Dip the white bottle again to refill.

Complete the Field Data Sheet (observations, stream flow, etc.). Store samples in a cooler with ice and transport to Concord DES Laboratory **within 24 hours**. Be sure the samples arrive in time to be analyzed that day (**before 2:00 PM**).

APPENDIX E

Water Quality Data